Technische Universität Braunschweig

GRK 2075

Vortrag im Gästeprogramm des GRK 2075

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From the plasticity of soil to railway track Geometry Degradation prognostics: An asset management perspective

Freitag, 14.12.2018, 10.00 Uhr
Institut für Wissenschaftliches Rechnen
Mühlenpfordtstrasse 23, 8. OG, Raum 812

Railway track degradation and maintenance modelling to date has a strong empirical retrospective character, mainly grounded on data-based models with limited prospective capability. The prediction accuracy of those models strongly depends on the quality and quantity of the available historic data, and thus they are prone to misjudgments especially under medium-to-long term future scenarios implying changing operational and environmental conditions. To overcome this limitation, some authors have investigated the mechanical behaviour of ballast materials under cyclic loading conditions and have proposed physics-based models to predict the progressive degradation of the track from first principles. However, a typical criticism of these models is that they are unable to account for the uncertainty in the predictions since they are based on deterministic input-output relationships. In this talk, a paradigm shift for track geometry degradation modelling and maintenance will be presented. Instead of making maintenance decisions based on either a retrospective data-based modelling of the track, or, alternatively, using a purely deterministic physics-based approach, a knowledge-based prognostics framework for track geometry degradation will be presented. This approach fuses information from an elasto-plastic model about yielding of soils and available data about track degradation within a Bayesian learning paradigm to sequentially reduce the initial modelling uncertainty in order to obtain increasingly accurate forecasts of the future condition of the track. These forecasts enable the testing of various load and utilisation scenarios, and more importantly, allow us to answer the question of "when will failure occur" with quantified uncertainty. This will be shown to be a key piece of information to enable informed, anticipated, and risk-based decisions about optimal railway track asset management.

The suitability of the proposed methodology will be demonstrated and discussed in a case study using data taken from a laboratory simulation of railway track degradation under cyclic loads, carried out at the University of Nottingham (UK). The results show that the proposed methodology is able to provide accurate predictions of the remaining useful life of the track after a model training period of about 10% of the process lifespan.

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Modelling self-adaptive expert systems for ageing Infrastructure asset management using plausible petri nets

Freitag, 14.12.2018, 11.00 Uhr
Institut für Wissenschaftliches Rechnen
Mühlenpfordtstrasse 23, 8. OG, Raum 812

Most existing infrastructures continue to grow in size and complexity, but also to age as a consequence of increasing demand of use. Accordingly, increasingly greater safety and economic challenges are coming into play in relation to the management of those infrastructures. Resilience engineering is nowadays getting higher attention as a key enabler to propitiate a paradigm shift in infrastructure management, as a way to make infrastructures capable of survive perturbations by adaptation and evolution by anticipation of changes in internal (and also environmental) conditions.
In parallel, developed countries are facing the onset of a new industrial revolution due to the rapid development of technologies including artificial intelligence, sensing and robotics. Infrastructures and the built environment will certainly be part of this revolution due to their massive impact on the economy and society, and the low cost of these new technologies in relation to the cost of the infrastructure. As a result, the amount of real-time data and information coming from monitored infrastructures is expected to increase exponentially over the coming decades. This information has the potential to reduce by billions the national expenditure on infrastructure asset management. Henceforth, there is a clear need to exploit the full potential of such infrastructure monitoring data by combining state-of the art artificial intelligent approaches with physics-based models for infrastructure operation and ageing, as a paradigm shift on what is typically known as Smart Infrastructure.

This talk focuses on the application of a Petri Net-based formalism to model self-adaptive expert systems, which are understood as expert systems with the ability to sequentially learn from data. To this end, a novel computational framework is proposed by combining the Bayesian learning principles with the Plausible Petri nets (PPNs) methodology, first developed in M. Chiachío et al. [Proceedings of the Future Technologies Conference, San Francisco, (2016), pp. 165-172]. In this research, the PPNs are used for their efficiency to jointly consider the dynamics of discrete event-driven systems together with uncertain knowledge representation about the system state, which offers the possibility of integrating in a natural way continuous and discrete dynamics in a single net model under consideration of uncertainty. This fact makes them useful for analysing hybrid systems with interaction of diverse sources of information, like in expert systems. The talk will also give the conditions whereby the Bayesian updating becomes a particular case of a more general basic operation within the PPN execution semantics, which allows the uncertain knowledge about the system state being updated from data in a rigorous manner. The approach is demonstrated in a self-adaptive expert system for railway track inspection management taken as case study using published data taken from a laboratory simulation of train loading and tamping on ballast, carried out at the Nottingham Railway Test Facility, University of Nottingham. The numerical results reveal how the uncertain information from measurements and Bayesian algorithms can be processed, transferred, stored, and integrated with discrete- event inspection activities for optimal nonlinear control operations at system level.